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An assessment of striped shrimp (Pandalus Montagui, Leach, 1814) stocks from Resolution Island south along the coast of Labrador to the Grand Banks.

Une évaluation des stocks de crevette ésope (*Pandalus montagui*, Leach, 1814) du sud de l'île Resolution le long de la côte du Labrador jusqu'aux Grands Bancs.

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ABSTRACT

This report details the May 2003 assessment of striped shrimp (*Pandalus montagui,* Leach, 1814) in the area off Resolution Island (SFA's 2, 3 and 4; west of 63^0 00 W). There is a commercial fishery in this area, but no recent fishery independent data. Status was inferred by examining trends in commercial catch, effort, catch-per-unit effort, fishing pattern and size/ sex/ age composition of the catches. An assessment of striped shrimp along the coast of Labrador and off the east coast of Newfoundland is also provided. Annual autumn multi-species bottom trawl surveys take place south of 2G, but the commercial striped shrimp fishery in this area is limited to bycatch in the *Pandalus borealis* fishery.

Current stock status off Resolution Island is uncertain in the absence of fishery-independent data. The fishery takes place in a small area and catch rates in 2002 were similar to those during 1995, 1997 and 2001 but significantly lower than during all other years.

In areas to the south, shrimp densities are lower and variable both within SFAs and between years. Aging was difficult to resolve because length frequencies were often jagged and lacked inter annual consistencies. Current stock status is uncertain. The patchy nature of distributions and low shrimp densities do not support a directed fishery for this resource. Striped shrimp are caught as a bycatch in the *P. borealis* fishery, therefore, fishing mortality is unknown.

RÉSUMÉ

Ce rapport expose les détails de l'évaluation de la crevette ésope (*Pandalus montagui,* Leach, 1814) effectuée en mai 2003 au large de l'île Resolution (ZPC 2, 3 et 4, à l'ouest de 63° 00' O). Bien que la pêche commerciale soit pratiquée dans cette région, aucune donnée récente indépendante de celle-ci n'est disponible. On déduit l'état de la ressource en crevettes d'après un examen des tendances des prises commerciales, de l'effort, des prises par unité d'effort, du patron de pêche et de la composition des prises selon la taille, le sexe et l'âge. On fait aussi une évaluation de la crevette ésope retrouvée sur le littoral du Labrador et la côte est de Terre-Neuve. Des relevés polyvalents d'automne au chalut de fond sont effectués tous les ans dans les eaux au sud de 2G, mais la pêche commerciale de la crevette ésope dans ces eaux est limitée à des prises accessoires récoltées dans le cadre de la pêche de *Pandalus borealis*.

L'état actuel du stock au large de l'île Resolution est incertain en l'absence de données indépendantes de la pêche. Celle-ci est pratiquée dans un secteur restreint. Les taux de capture en 2002 se rapprochaient de ceux obtenus en 1995, 1997 et 2001, mais ils étaient nettement inférieurs à ceux obtenus toutes les autres années.

Dans les secteurs plus au sud, les concentrations de crevette sont moins denses et varient à l'intérieur des ZPC et d'une année à l'autre. Il a été difficile de déterminer l'âge des prises car les distributions de la fréquence des longueurs étaient souvent irrégulières et manquaient d'uniformité d'une année à l'autre. Il n'est donc pas clair dans quel état est le stock. Les distributions en nuage et les faibles densités de crevette écartent la possibilité d'une pêche dirigée de cette ressource. Comme la crevette ésope fait partie des prises accessoires de la pêche de *P. borealis*, son taux de mortalité par pêche est inconnu.

INTRODUCTION

The commercial fishery for striped pink shrimp (*Pandalus montagui,* Leach, 1814) began in the eastern Hudson Strait - Ungava Bay area in 1980 (Parsons *et al.* 1981, 1983, 1987 and 1996). Annual precautionary TACs of 100 - 300 tons were implemented for the 1978 - 1982 period and were later increased to 850 tons for the period 1983 – 1986, based on estimates of trawlable biomass obtained from a survey in 1982. TACs were increased to 1200 tons in 1987, following high catch rates (> 7 tons per hr) obtained by one vessel in 1986. These catch controls applied specifically to *P. montagui* in the Hudson Strait - Ungava Bay area between 64^0 30' and 70^0 W, which became known as Shrimp Fishing Area (SFA) 3.

However, the 1995 fishery shifted well to the east, primarily into Division 0B (SFA 2), where catches were often mixed with pink shrimp (*Pandalus borealis*, Kroyer, 1838). A review, conducted in spring 1996, concluded that the 1995 fishery exploited the same *P. montagui* population previously fished within SFA 3 and that the resource might be best protected by applying the TAC for *P. montagui* to SFAs 2, 3 and 4 west of 63^0 W (Parsons et al., 1996). There was no biological basis on which to advise a change in the TAC of 1200 tons. However in 1996, a 3800-ton catch limit was established for the larger management area. Between 1997 and 2001, catches were maintained at a high level ranging from 2800 to 4200 tons. Then in 2002, the limits were increased to 6300 tons to aid development of this fishery.

The major geographic shift in the fishery, the recent increases in both TAC and catch, and the fact that the last assessment was conducted in 1996 created a need to update *P. montagui* stock status. The update presented within this assessment contains fishery information, collected in the Resolution Island area, as well as information collected by the multi-species surveys, which occur south of 0B. It is hoped that this work will contribute to a precautionary approach for the management of this fishery.

MATERIAL AND METHODS

Commercial fishery data

Catch-per-unit effort (CPUE) was calculated (kg/hr) by year and is used as an indicator of change in the fishable stock over time. The CPUE series was limited to that period after 1995, because catches prior to 1995 were taken west of Resolution Island and were the result of a combination of exploratory, experimental, directed (from one to several vessels) and opportunistic fishing (Parsons *et al.* 1996). After 1995, a directed striped shrimp fishery became established southeast of Resolution Island. Observer datasets, rather than logbook datasets were used because we wanted to account for the usage of windows (escape openings in the trawls). The usage of windows is captured in the observer dataset but not in the logbooks. In order to track only experienced fishers, and to reduce the number of estimated parameters, vessels with less than three years of experience were excluded from the analyses. This increased our confidence when interpreting results. Records indicating more than one trawl, and/ or the presence of windows, were omitted from the CPUE calculations. Raw catch/ effort data for each SFA were standardized by multiple regression, weighted by effort, in an attempt to account for variation due to year, month, area and vessel effects. The multiplicative model has the following logarithmic form:

$$\ln(CPUE_{ijkl}) = \ln(u) + \ln(A_i) + \ln(S_j) + \ln(V_k) + \ln(Y_l) + e_{ijkl}$$

Where: $CPUE_{ijkl}$ is the CPUE for vessel k, fishing in area i in month during year l (k=1,.....,a; j=1,.....,s; i=1,.....,y);
$ln(u)$ is the overall mean ln(CPUE);
A_i is the effect of the i^{th} area;
S_j is the effect of the j^{th} *month;*
V_k is the effect of the k^{th} vessel;
Y_l is the effect of the l^{th} *year;*
e_{ijkl} is the error term assumed to be normally distributed $N(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

The standardized CPUE indices are the antilog of the year coefficient.

Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 2002 YEAR parameter estimate and those of previous years was inferred from the output statistics.

Observed catches were plotted using ACON (Black, 2001). The area fished each year was divided into 10-min. X 10-min. cells, catches were aggregated by cells and aggregated catches were organized into a cumulative percent

frequency (cpf). The cpf was used to determine the number of cells accounting for 95% of the catch each year (Swain and Morin, 1996). The plots and quantification of spatial coverage were used in describing changes in fishing patterns and practices that might affect CPUE interpretations.

Sizes of male and female shrimp in the catches were obtained from samples taken by observers. Samples were adjusted upward to set, month and year to derive a series of annual catch-at-length compositions. Annual carapace length frequencies were plotted to compare size composition, evaluate relative year class strength, and track the progression of year classes.

Research survey data

Shrimp abundance, biomass, maturity and carapace length data have been collected since autumn 1995, as part of the Canadian multispecies bottom trawl surveys conducted using the CCG Wilfred Templeman, CCG Alfred Needler and CCG Teleost. Fishing sets of 15 minute duration and a towing speed of 3 knots were randomly allocated within strata, to depths of 1500 m. The surveys have a target of one sample per 350 sq. Nmi, with a minimum of two samples per stratum. Both vessels used a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 12.7-mm liner. SCANMAR sensors estimated that the mean wingspread was 16.8 m. Details of the survey design and fishing protocols are outlined in Brodie (1996) and McCallum and Walsh (1996).

During 1999, it was decided that future surveys would extend to the top of 2H in alternate years. During intervening years, the survey would extend to the top of 2J. NAFO division 2H was surveyed during 2001, however, due to vessel problems, 2H were surveyed during December rather than October. The CCG ALFRED Needler rather than the CCG Teleost surveyed much of 2H and approximately ten fishing locations were not occupied in the southeastern corner of 2H. NAFO divisions 2J3K were surveyed during 2002. Vessel problems re-occurred during 2002. Most of 2J and parts of 3K were surveyed during the first two weeks of January, 2003 rather than October 2002. A research survey has not been conducted in 2G since 1999 and has never been conducted in 0B.

Shrimp were frozen and returned to the Northwest Atlantic Fisheries Centre where identification to species and maturity stage was made. The maturity of the shrimp was defined by five stages:

males;
transitionals;
ovigerous;
primiparous females;
and multiparous females

as described by Ramussen (1953), Allen (1959) and McCrary (1971).

Oblique carapace lengths (0.1 mm) were recorded while total number and weight per set were estimated. Shrimp were combined into 0.5 mm carapace length bins for length based analysis.

Abundance and biomass estimates with Monte Carlo confidence intervals were calculated using a non-parametric method known as OGive MAPping (OGMAP) (Evans *et al.*, 2000). Abundance at length and sex were also derived using this technique. Mix 3.2a (MacDonald and Pitcher, 1988) and the deviation method (Skűladóttir, 1981) were tried as means of determining age structure from composite length frequency distributions obtained from survey data.

RESULTS

FISHERY DATA

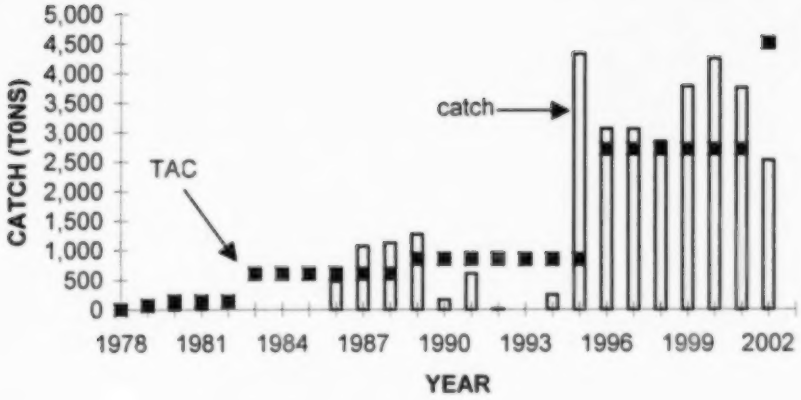
Catch and effort

The fishery for *P. montagui*, in the area west of Resolution Island, largely depended on the existence of favorable markets for the species, the maintenance of high catch rates and the relative performance of the fishery for *P. borealis* in other areas. These factors, coupled with some past concerns for environmental sensitivity (the importance of shrimp as prey for marine fish and mammals) resulted in a sporadic fishery beginning in the late 1970's. After an initial increase in catch from 92 tons in 1979 to 236 tons in 1980, fishing virtually ceased until 1986 when 476 tons were taken. From 1987 to 1989, catches remained near the TAC level of 1200 tons but subsequently declined remaining low (or zero) until 1994.

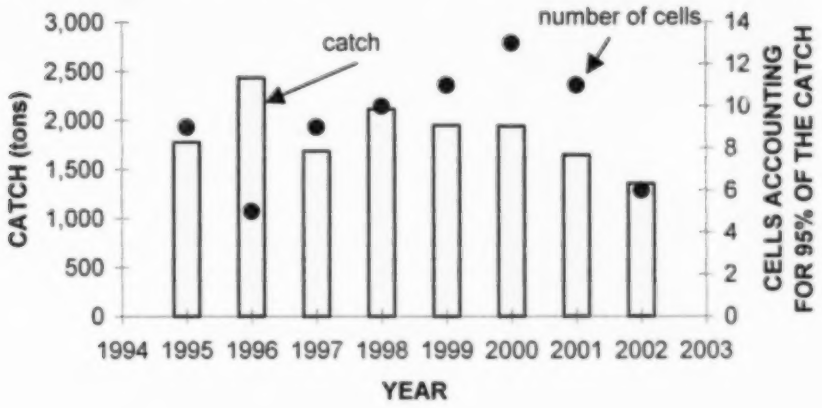
Fishing activity prior to 1995 occurred primarily in a limited area, southwest of Resolution Island. Occasionally, a small area in Ungava Bay, west of Port Burwell, was also fished. Then in 1995, fishing began to concentrate southeast of Resolution Island, outside of SFA 3 (Figure 1). This activity was the result of exploratory fishing for northern pink shrimp (*P. borealis*) in SFA 2 rather than directed fishing for striped shrimp. Catches contained both species, in varying proportions but, as vessels moved closer to Resolution Island, the catches became almost entirely *P. montagui*. This newfound resource was either a relocation or an extension of the Hudson Strait stock.

Estimated catches, in 1995, far exceeded the TAC of 1,200 t and the fishery was closed by restricting vessels to areas east of 62^0 W where by-catches of this species in the *P. borealis* fishery were known to be low.

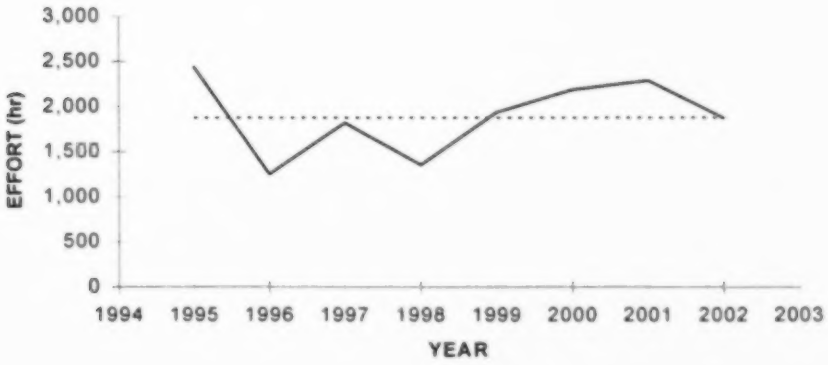
In 1996, the *P. montagui* catch limit was increased to 3800 tons to account for the expansion of the fishery into SFA 2. Catches of striped shrimp within SFAs 2, 3 and 4, west of 63^o 00' W were to be counted against the quota. One thousand tons from this catch limit were set aside for the Nunavut Settlement Area (NSA), during 1996. Then in 1997, a 500-ton quota was created for the Nunavut Inuit, inside the NSA. Between 1997 and 2001, catches were maintained at a high level ranging from 2800 to 4200 tons. Then in 2002, the limits were increased to 6300 tons to encourage development of this fishery. This was a 2,500 t exploratory quota allocated to the Nunavut Wildlife Management Board (NWMB) and was to be harvested within the NSA. Accordingly, 2000 tons were to be harvested east of 64^0 30'W while 500 tons were to be harvested west of this line (Table 1).



Prior to 1995, fishing was mainly from August until October, when the area was free from ice. When the fishery moved southeast of Resolution Island the season continued until December because of a longer ice-free period. Between 1996 and 2000, the amount of area fished to obtain 95% of the catch increased to 13 but have subsequently decreased to 6 cells by 2002.



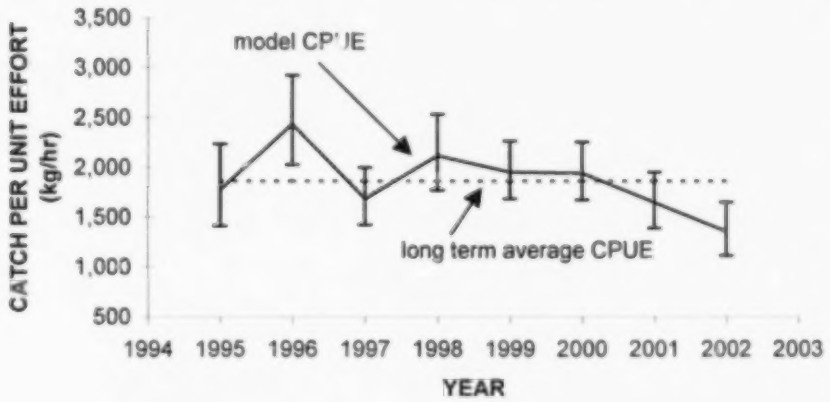
Standardized effort (catch/CPUE) tracks these changes in catch and activity.



Catch per unit effort (CPUE)

Unstandardized large vessel CPUEs (single trawl, no windows) were generally lower prior to 1995, when the fishery was prosecuted west of Resolution Island. The post 1994 period was analyzed by multiple regression for year, month and vessel effects to standardize catch rates (Table 2.). The standardized residuals do not indicate systematic patterns therefore, one may conclude that model assumptions were not violated Figure 2.

The CPUE accounted for 37% of the variance in the data. It increased from 1995 to 1996, decreased in 1997 and varied without trend thereafter. The 2002 estimate is similar to the 1995, 1997 and 2001 values. All other estimates are significantly higher than the 2002 estimate (Table 2). The figure below indicates the 95% confidence interval around the model estimates.

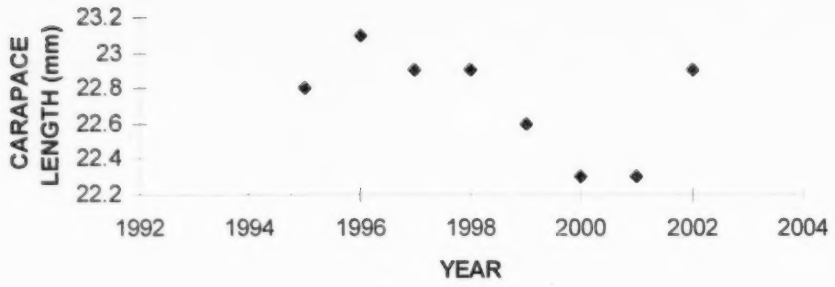


Size composition

Catch-at-length, estimated from observer length frequencies indicated a dominant female mode at 22 - 24 mm carapace length (CL) and up to three smaller male modes occurring at roughly 16, 18 and 20 mm CL mm (Figure 3). Size groups within the length distributions may reflect age composition making it possible to follow the progression of strong year classes. For instance, the 15-16 mm mode in 1998 may be followed to 17-18 mm in 1999, 19 mm in 2000 and finally changing to female at 22 mm during 2001. However, the details of age and growth for this species in the northwest Atlantic have not been resolved. Parsons *et al.* (1987) concluded that aging of female *P. montagui* by conventional methods (modal analysis and sternal spine characteristics) was highly uncertain.

During 1995 – 2001, mean size of females and the size at sex inversion declined slightly, indicating a possible change in growth, mortality and maturity schedule, within the area. The mean size of females and size at sex inversion returned to 1998 levels (22.9 mm; 21.0 mm respectively) during 2002.

TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY



By comparing the 1994 and 1995 length frequency distributions with those from previous years, Parsons *et al.* (1996) concluded that striped shrimp caught southeast of Resolution Island were probably from the same population as those west of the Island. The last research survey into Hudson Strait – Ungava Bay and NAFO division 0B was completed in 1982 and there has been little commercial effort west of Resolution Island since 1994, therefore, it was not possible to continue this comparative work.

Catches off Baffin Island, Labrador and northeastern Newfoundland

Striped shrimp are found from Greenland and Hudson Bay to Rhode Island in the western Atlantic (Squires, 1990) and are taken, throughout SFAs 2, 3, 4, 5 and 6, by large shrimp fishing vessels. However, with the exception of the resource off Resolution Island, catches are sporadic and relatively low. Catches elsewhere are generally taken as by-catch within the northern shrimp (*P. borealis*) fishery (Table 3).

RESEARCH SURVEY DATA

Stock size

Results of the 1995 – 2002 autumn multi-species research survey indicate that striped shrimp are distributed over a wide geographic range. In general, the species tends to be found further inshore and in shallower water (<400 m) than *Pandalus borealis* (200 – 600 m) (Lilly *et al.* 1998). Multi-species surveys take place in water deeper than 100 m and at times cover only offshore areas, therefore, it was not possible to determine the minimum depth range or the inshore distribution of *P. montagui* .

Figures 4 – 7 provide the densities of striped shrimp obtained during the 1995 – 2002 autumn multi-species surveys. Very low densities of striped shrimp were present around the Grand Banks (Figure 4). Northward densities increase.

There are relatively dense patches along the edges of Cartwright Channel, at the northern tip of Hopedale Channel (Figure 6) and along the northern edge of 2G (Figure 7). Most of the by-catch is taken in these areas.

Table 4 provides OGMAP abundance and biomass estimates with Monte Carlo confidence limits. The confidence limits are broad suggesting that there is a great deal of variation between catches. Table 4 also indicates that there is considerable inter annual variability. Both of these phenomena are may be attributed to the patchy nature of striped shrimp distributions (Figures 4-7). There are no clear trends in biomass or abundance within any of the shrimp fishing areas. The average of the lower 95% confidence limit around biomass and abundance estimates was used an indicator of minimum stock size.

SFA	n	average of the lower 95% C.I. Biomass (tons)	average of the lower 95% C.I. Abundance (10^6)	SFA Area (sq. km)
4	4	3,640	821	43,530.6
5	5	9,748	2,088	60,578.6
6	7	15,638	3,318	171,048.5
7	7	8,089	1,465	266,897.4

These indices are low compared to those estimated for *Pandalus borealis* from the same surveys.

Stock Composition

Length distributions are presented in Figures 8 – 11. The males range in size from 7.5 mm – 22 mm. Transitionals ranged in size from 10 – 22 mm. Females from SFAs 4 – 6 ranged in size from 14 – 27 mm. However, the female length frequency distribution within SFA 7 ranged between 10 and 22 mm (Figure 8). The smaller females were probably primary, or early maturing, females. This is in agreement with Squires (1990) who notes that primary females were present and maturity appeared to take place faster in areas where the water was warm.

Length frequencies were often jagged obscuring any modal structure, which might otherwise provide a basis for aging. Therefore modal analysis was not an effective means of resolving age composition. The jagged nature of the length frequencies was probably due to the low number of striped shrimp caught in each SFA. As Parsons *et al.* (1987) noted, aging of the species is uncertain and attempts should be made to obtain a time series of data, both within and between years, to study growth more closely and develop appropriate aging techniques.

RESOURCE STATUS

The status of the striped shrimp stocks within 0B, 2G and the Hudson Strait – Ungava Bay area, west of 63°W, is uncertain. Distribution, in the north, appears concentrated within specific areas as evidenced in the long-term commercial fishing patterns. Prior to 1994 the fishery occurred in two areas west of Resolution Island, and has since been fished in a larger area southeast of Resolution Island. The commercial CPUE southeast of Resolution Island initially increased to 2,500 kg/hr but had dropped to 1,700 kg/hr in 1997 and has fluctuated at a relatively low level since. The average size of the females decreased between 1998 and 2001, but then returned to 1998 sizes in 2002. Since there are no research surveys north of 2G, the population size structure and distribution of the resource remain unknown, therefore exploitation levels can not be inferred. Additionally, we lack basic knowledge about northern environments (temperature regimes, predator/prey relationships). The lack of information to conduct a comprehensive assessment increases the uncertainty of resource status and concern for future prospects.

South of 0B, shrimp distributions are patchy. The patchy nature of the distributions resulted in OGMAP point estimates that were variable both within years and between years. Shrimp concentrations are both scarce and elusive.

The patchy distributions and low numbers of shrimp resulted in variable and jagged length frequencies that could not be used to infer ages. To compound the aging problem, primary females were present within samples taken from NAFO division 3LNO. Thus maturity stage could not be used as an aid in aging. A great deal of work will have to be completed in order to understand growth patterns and infer ages from striped shrimp length frequencies.

The current stock status south of 0B is uncertain. Striped shrimp occur as bycatch in the fishery for *P. borealis*. However, since there are no reliable estimates of catch, effects of fishing remain unknown.

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TABLE 1. STRIPED SHRIMP *(Pandalus montagui)* LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 0B,2G, HS-UB, 1979 - 2002.

YEAR	TAC [1] (t)	FLEET CATCH [2] (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	EFFORT [3] (HR)	STANDARDIZED RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
1979	100	92	213		432			
1980	200	236	912		259			
1981	200	13	331		39			
1982	200							
1983	850							
1984	850							
1985	850							
1986	850	476	7,885	4.72	60			
1987	1,200	1,069	2,250	1.35	475			
1988	1,200	1,125	1,572	0.94	716			
1989	1,200	1,269	1,109	0.66	1,144			
1990	1,200	164	924	0.55	177			
1991	1,190	605	580	0.35	1,043			
1992	1,190	3	656	0.39	5			
1993	1,190							
1994	1,200	244	487	0.29	501			
1995	1,200	4,323	2,175	1.30	1,988	1.31	1,776	2,435
1996	3,800	3,053	2,321	1.39	1,315	1.80	2,434	1,254
1997	3,800	3,049	1,501	0.90	2,031	1.24	1,685	1,809
1998	3,800	2,841	1,852	1.11	1,534	1.56	2,115	1,343
1999	3,800	3,774	1,866	1.12	2,022	1.44	1,950	1,935
2000	3,800	4,238	2,005	1.20	2,114	1.43	1,940	2,185
2001	3,800	3,751	1,881	1.13	1,994	1.22	1,646	2,279
2002	6,300	2,517	1,669	1.00	1,508	1.00	1,354	1,859

[1] TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC's FROM 1996 ONWARD APPLIED TO SFAS 2, 3 AND 4 WEST OF 63° W.

[2] CATCH (TONS) AS REPORTED IN: LOGBOOKS FOR 1979, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1980 TO 1989, YEAR-END QUOTA REPORTS AND/OR LOGBOOKS FROM 1990 - 1996, AND OBSERVED DATA, THEREAFTER.

[3] EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 2. Multiplicative, year, month, vessel CPUE model for large vessels (>500 t) fishing striped shrimp east of Resolution Island 1995 – 2002, weighted by effort (single trawl, no windows, observer data).

The GLM Procedure

Class Level Information

year	8	1995 1996 1997 1998 1999 2000 2001 2002
month	7	6 7 9 10 11 12 13
CFV	14	

Number of observations 244

Dependent Variable: lncpue

Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	829.710121	31.911928	4.98	<.0001
Error	217	1391.114893	6.410668		
Corrected Total	243	2220.825014			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.373604	34.03493	2.531930	7.439210

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	7	165.8466288	23.6923755	3.70	0.0009
month	6	249.9534164	41.6589027	6.50	<.0001
CFV	13	413.9100761	31.8392366	4.97	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	7	197.3764383	28.1966340	4.40	0.0001
month	6	284.5566180	47.4261030	7.40	<.0001
CFV	13	413.9100761	31.8392366	4.97	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		6.321099765 B	0.27030312	23.39	<.0001
year	1995	0.271051805 B	0.14530075	1.87	0.0635
year	1996	0.586212072 B	0.12904535	4.54	<.0001
year	1997	0.218779234 B	0.12581059	1.74	0.0835
year	1998	0.445970692 B	0.12727341	3.50	0.0006
year	1999	0.364709537 B	0.11220124	3.25	0.0013
year	2000	0.359419295 B	0.10478461	3.43	0.0007
year	2001	0.195330633 B	0.11312913	1.73	0.0857
year	2002	0.000000000 B	.	.	.

yearf	lncpue LSMEAN	95% Confidence Limits	
1995	7.481951	7.251909	7.711993
1996	7.797111	7.614107	7.980115
1997	7.429679	7.260062	7.599295
1998	7.656870	7.477871	7.835869
1999	7.575609	7.427514	7.723704
2000	7.570319	7.420551	7.720087
2001	7.406230	7.236519	7.575941
2002	7.210899	7.014690	7.407109

Table 3. Striped shrimp (*Pandalus montagui*) catches (tons) taken by large vessels (=>500 t) in 0A (SFA 1), 0B east of 63^0 00'W (SFA 2), 0B + 2G + Hudson Strait - Ungava Bay west of 630 00'W (SFA 3), 2G east of 630 00'W (SFA 4), Hopedale + Cartwright Channels (SFA 3), Hawke + 3K (SFA 6) and 3LNO (SFA 7) over the period 1979 - 2002.

(+ means that were greater than 0 but less than 1 ton)

Year	SFA 1	SFA 2	SFA 3	SFA 4	SFA 5	SFA 6	SFA 7
1979	1		92				
1980			236				
1981			13		8		
1982							
1983							
1984							
1985							
1986			476				
1987	4		1,069				
1988			1,125				
1989			1,269				
1990			164				
1991			605		+		
1992	3		3			1	
1993					3		
1994		4	244		2		
1995		5	4,323	+			
1996		3	3,053	8	175		
1997			3,049		95	22	
1998		13	2,841	15	157		
1999	4	13	3,774		416	11	
2000		+	4,238	58	275	82	2
2001	+	1	3,729	8	523	146	+
2002		21	2,530	12	130		

Catches (tons) in SFAs 1, 2, 4, 5, 6, and 7 from logbooks prior to 1999, afterward from Observer datasets.
Catches (tons) in SFA 3 from logbooks and yearend quota reports prior to 1999, afterward from Observer datasets.

Table 4 Striped shrimp (*Pandalus montagui*) abundance and biomass estimates by shrimp fishing area. Data are from autumn multi-species research surveys.

NAFO division 2G (SFA 4)
area compared each year = 43,530.6 sq. km.

	Biomass (tons)			Abundance (numbers x 10^{-6})			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	2,610	7,700	14,000	577	1,433	2,400	47
1997	3,180	8,600	14,920	683	1,729	2,970	69
1998	1,960	4,000	7,110	493	956	1,670	34
1999	6,810	27,900	42,900	1,530	5,687	8,710	69

Hopedale - Cartwright Channels (SFA 5)
Area compared each year = 60,578.6 sq. km.

	Biomass (tons)			Abundance (numbers x 10^{-6})			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	13,800	50,850	101,000	3,070	9,375	17,700	111
1997	7,580	14,950	22,800	1,500	3,090	4,790	111
1998	5,820	11,850	19,400	1,200	2,445	3,970	119
1999	9,240	15,000	22,300	1,860	2,965	4,510	117
2000							
2001	12,300	18,900	29,100	2,810	4,335	6,510	90

Hawke + 3K (SFA 6)
Area compared each year = 171,048.5 sq. km.

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	17,200	22,000	27,700	3,200	4,088	5,011	195
1996	26,900	36,900	57,900	5,260	7,196	10,500	238
1997	17,200	21,500	28,000	3,550	4,551	5,930	232
1998	14,300	17,900	24,000	2,820	3,531	4,750	234
1999	11,200	15,600	22,000	2,370	3,149	4,170	233
2000	14,500	23,300	36,900	3,130	4,684	6,550	241
2001	13,800	18,300	27,500	3,420	4,372	6,240	252
2002	10,000	13,500	22,250	2,792	3,476	5,120	253

NAFO divison 3LNO (SFA 7)
Area compared each year = 266,897.4 sq. km.

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	5,210	9,110	15,500	798	1,450	2,560	337
1996	8,260	11,300	15,300	1,670	2,320	3,170	336
1997	17,200	21,950	28,000	1,880	2,385	3,040	352
1998	4,810	6,640	8,990	1,010	1,310	1,690	381
1999	6,190	9,615	14,200	1,220	1,750	2,360	313
2000	6,740	10,300	15,200	1,480	2,020	2,670	370
2001	8,210	11,900	17,100	2,200	2,910	3,710	396

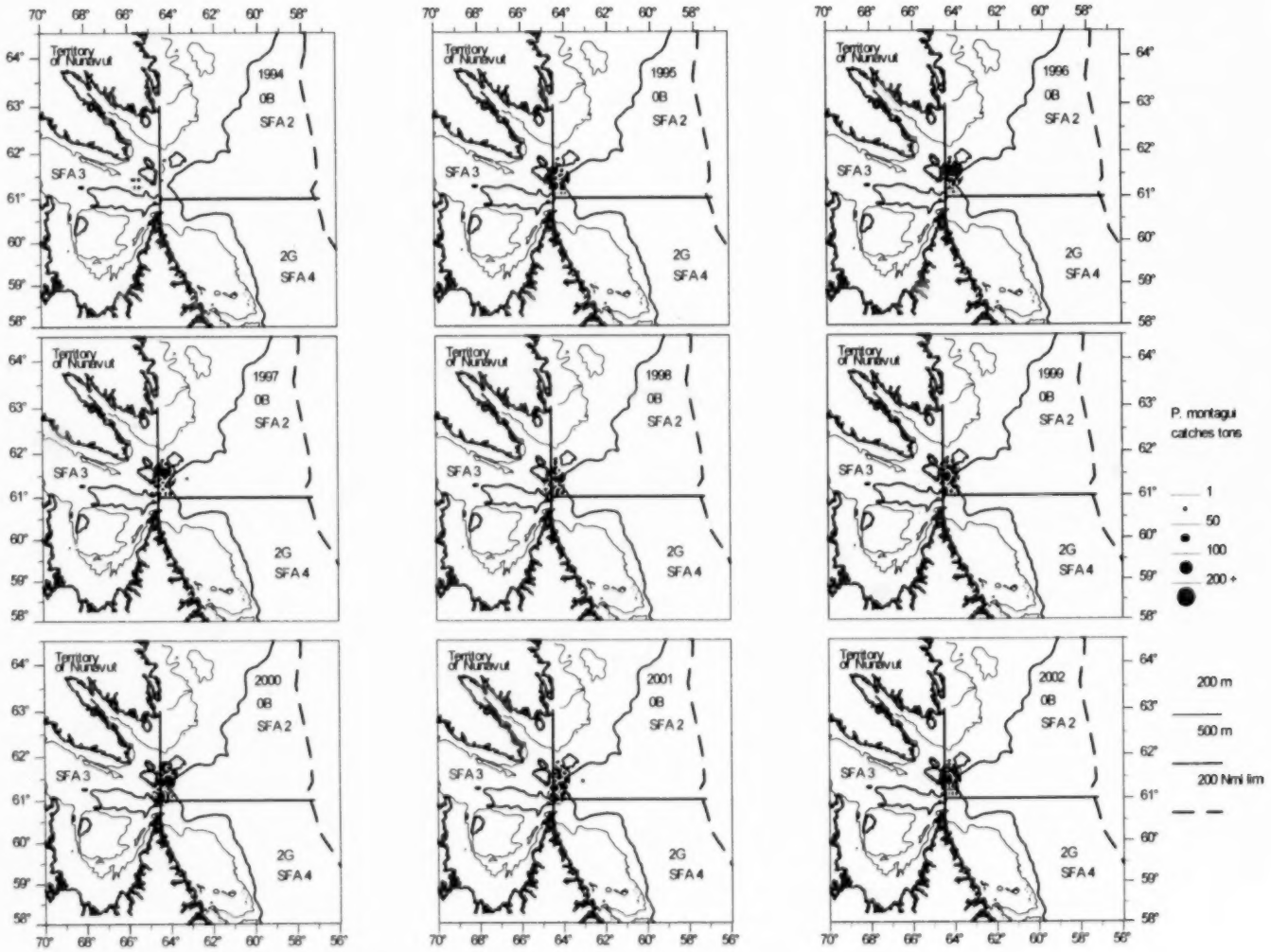
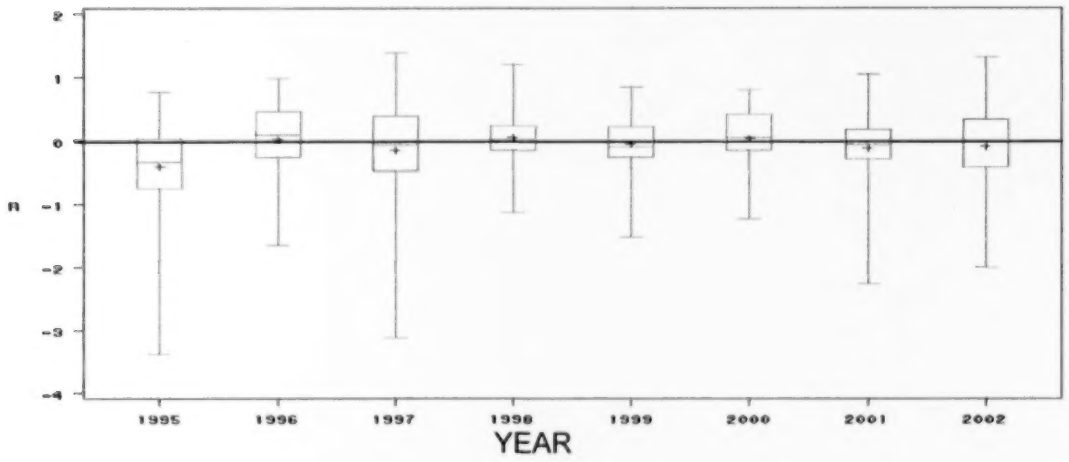
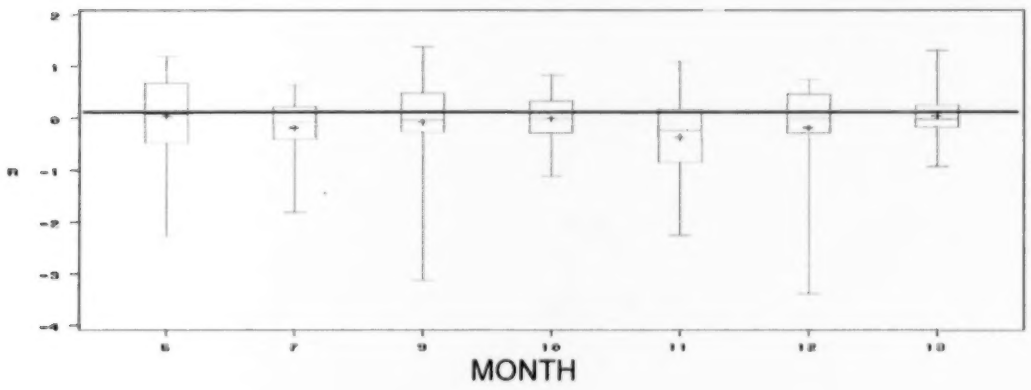


Figure 1 Distribution of large vessel (>500 t) catches (tons) in (SFA 3), 1994-2002. (Observer Data aggregated into 10 min. squares.)

Figure 2. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for large vessels fishing striped shrimp in SFA 3, 1995 – 2002.





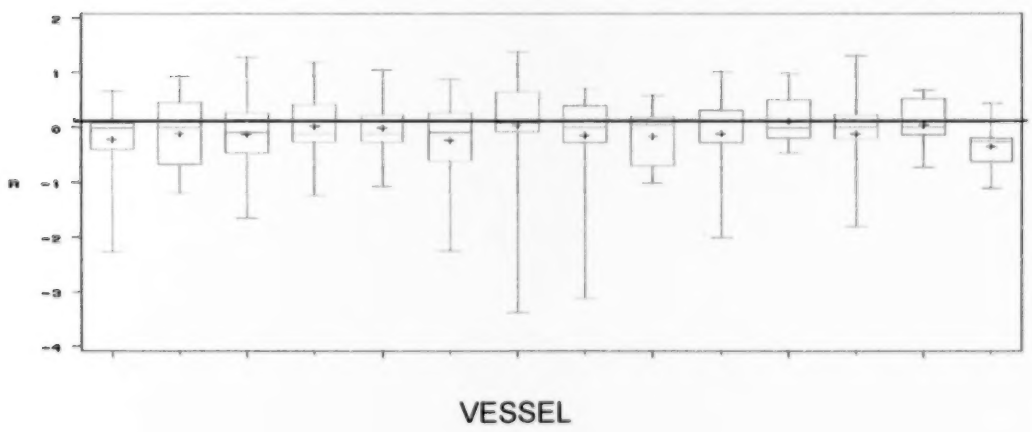
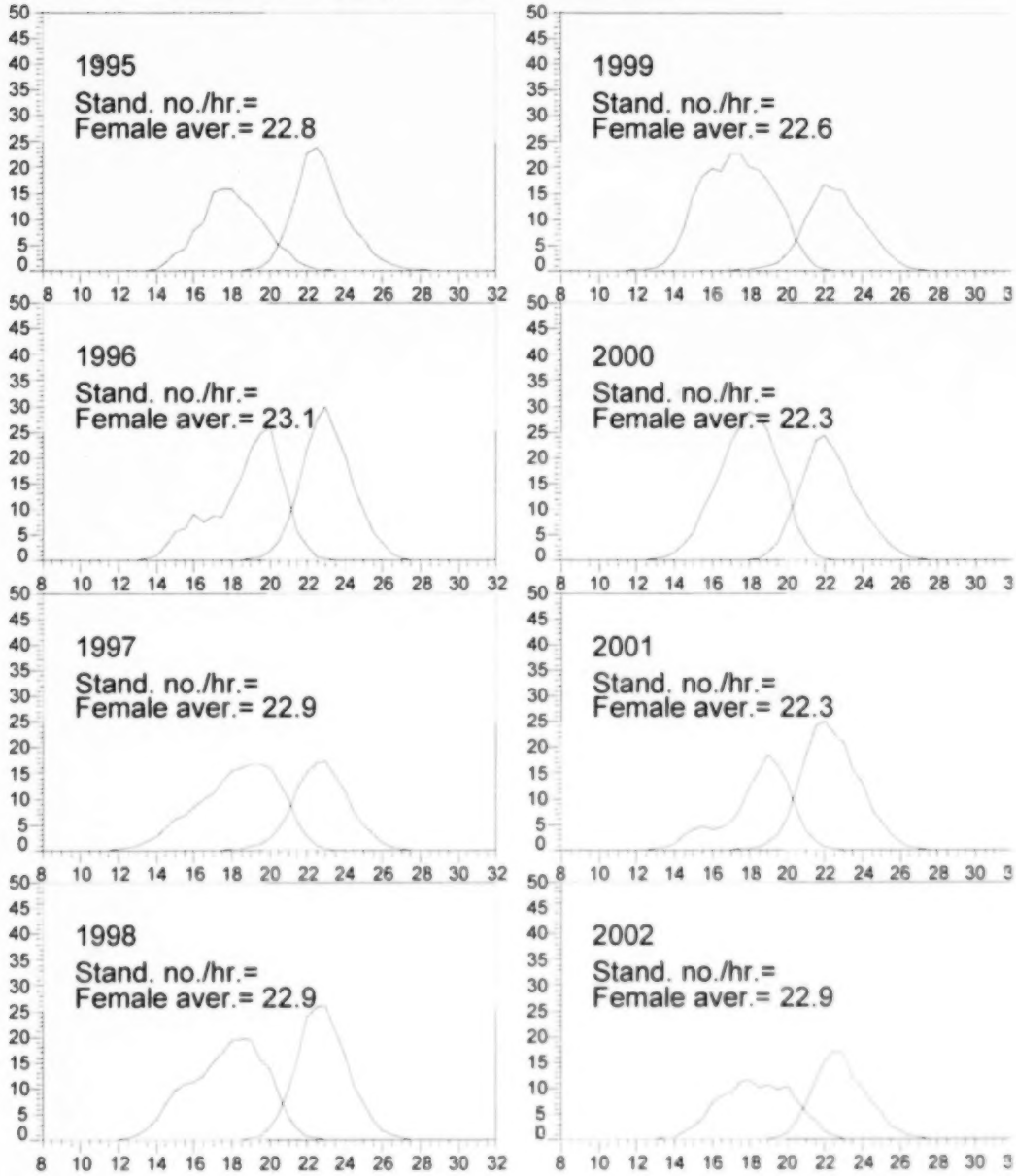


Figure 3. Standardized large vessel (>500 t) striped shrimp catch in number per hour (000's) east of Resolution Island (SFA 3), 1995 – 2002. Solid line = males; broken line = females.



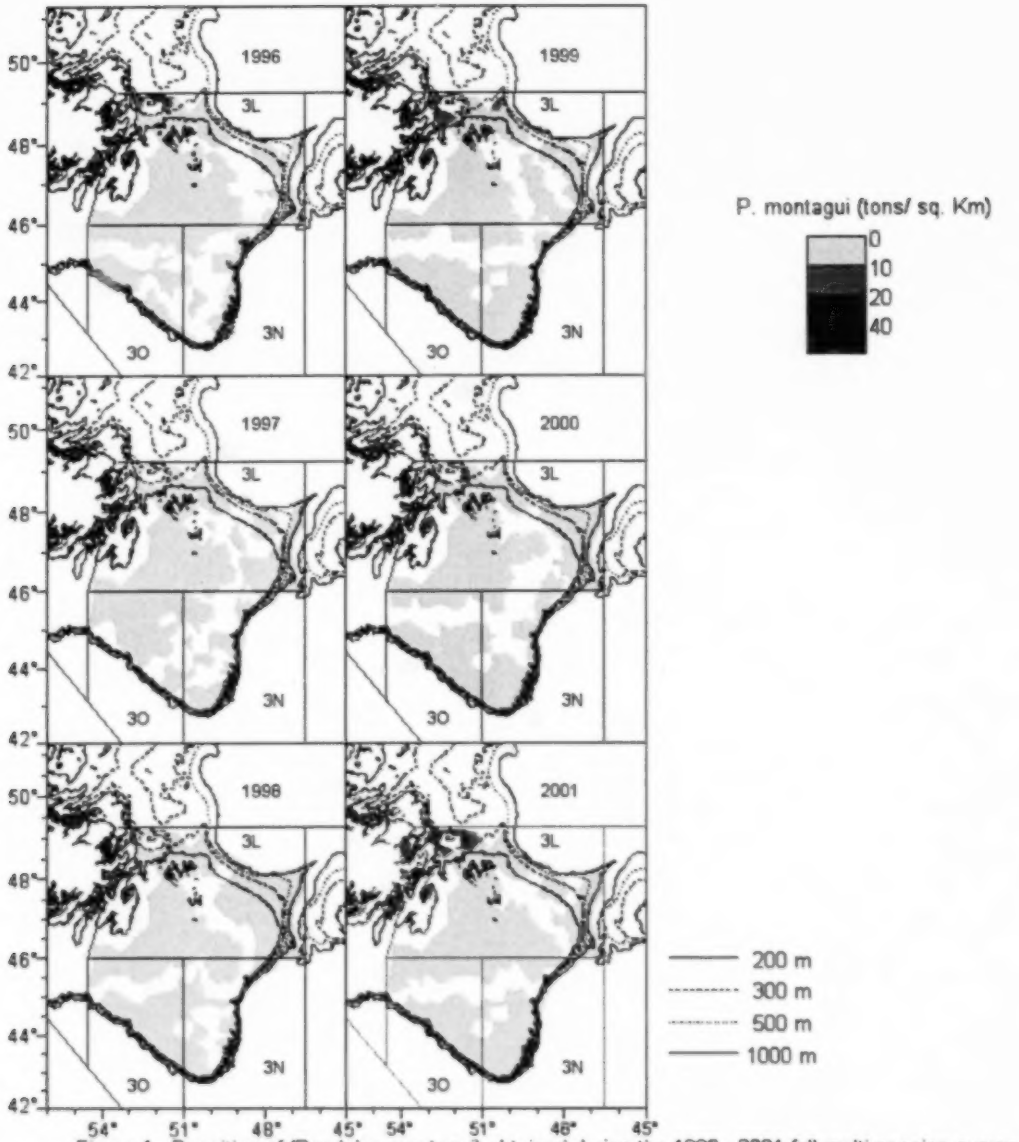


Figure 4 Densities of (Pandalus montagui) obtained during the 1996 - 2001 fall multi-species survey: into NAFO Divisions 3LNO (SFA 7) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

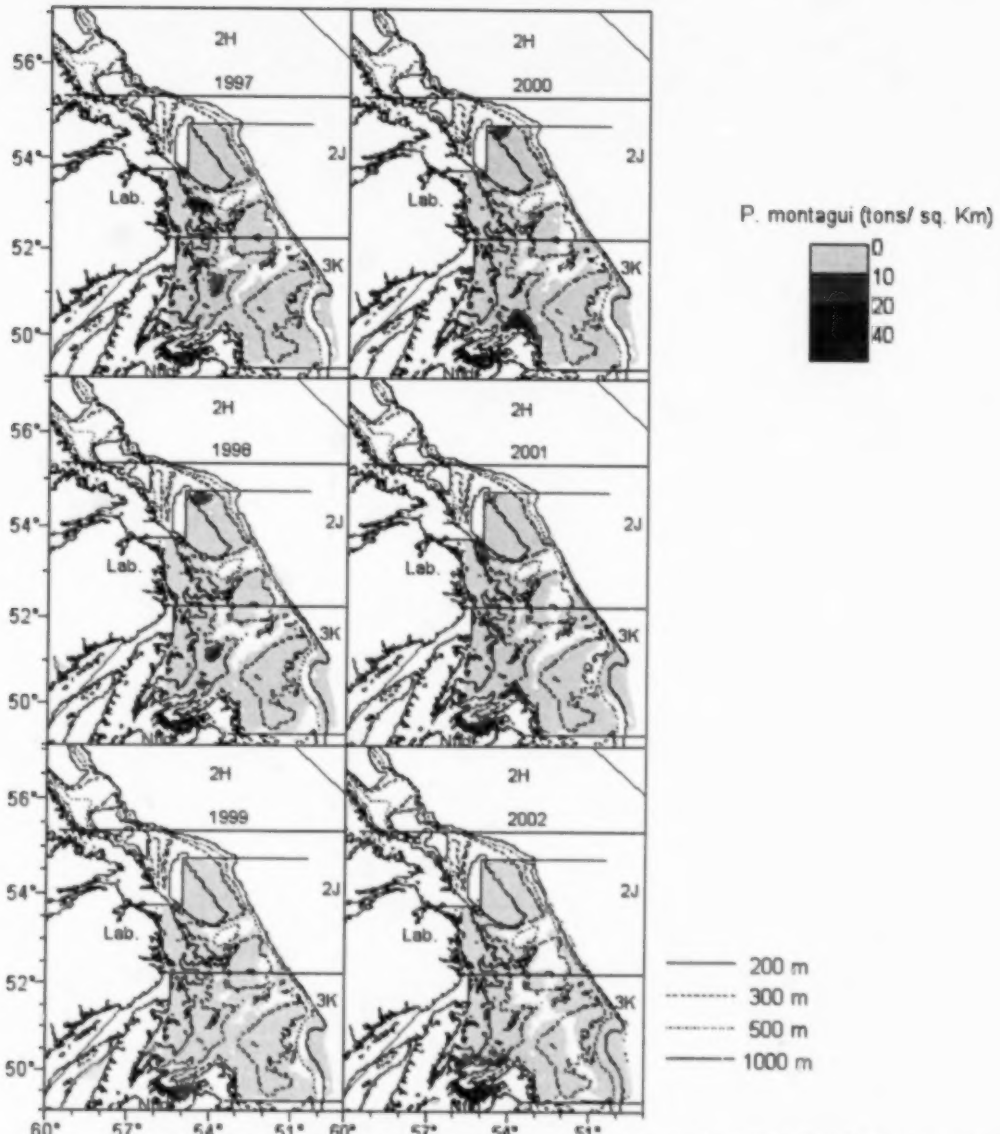


Figure 5 Densities of shrimp (Pandalus montagui) obtained during the 1997 - 2002 fall multi-species into Hawke Channel + 3K (SFA 6) using a Campelen 1800 shrimp trawl. (standard 15 min. tow

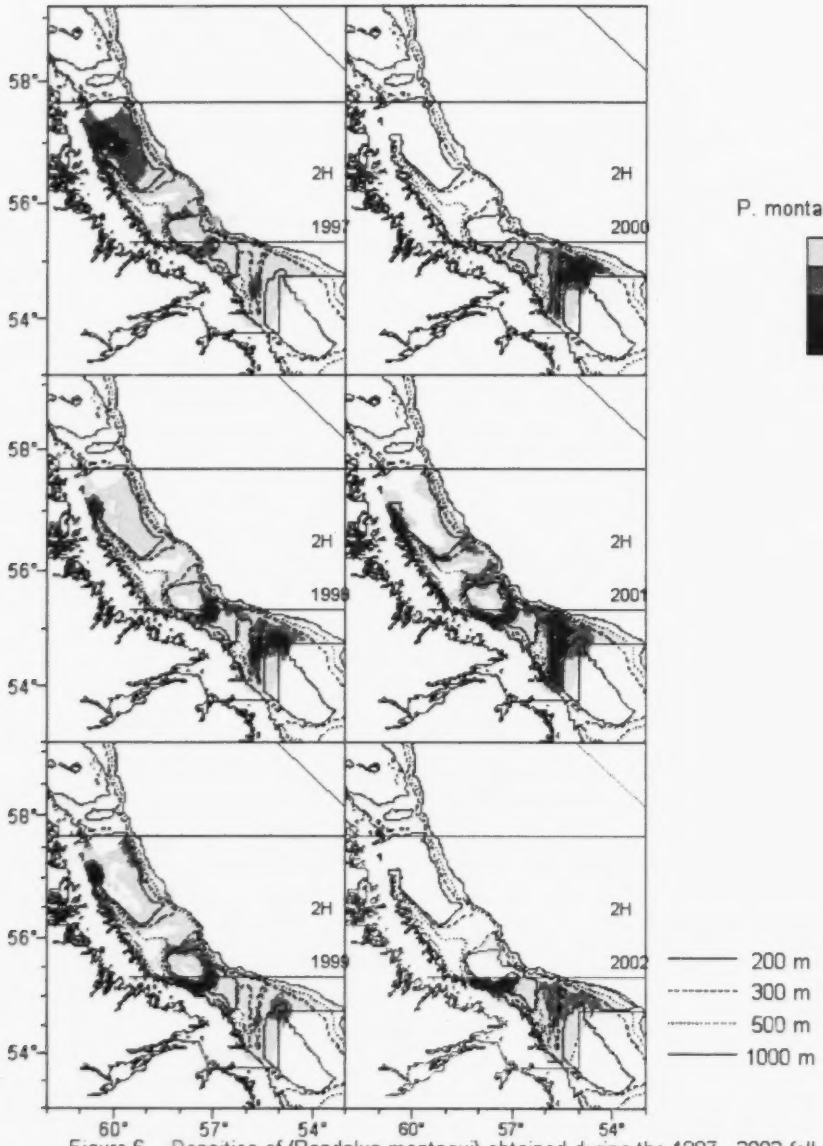


Figure 6 Densities of (Pandalus montagui) obtained during the 1997 - 2002 fall multi-species survey: into Hopedale and Cartwright Channels (SFA 5) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

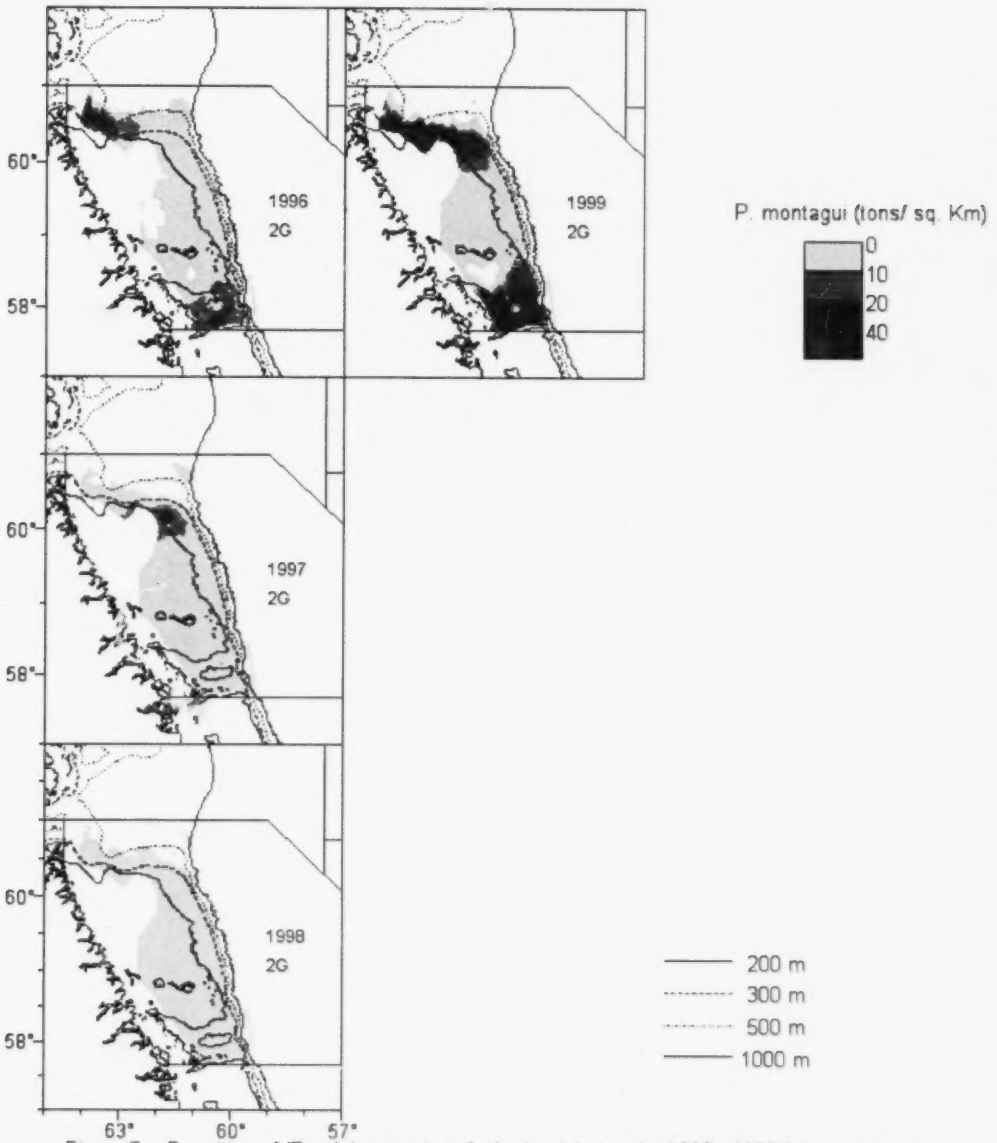


Figure 7 Densities of (Pandalus montagui) obtained during the 1996 - 1999 fall multi-species survey into NAFO Division 2G (SFA 4) using a Campelen 1800 shrimp trawl. (standard 15 min. tows)

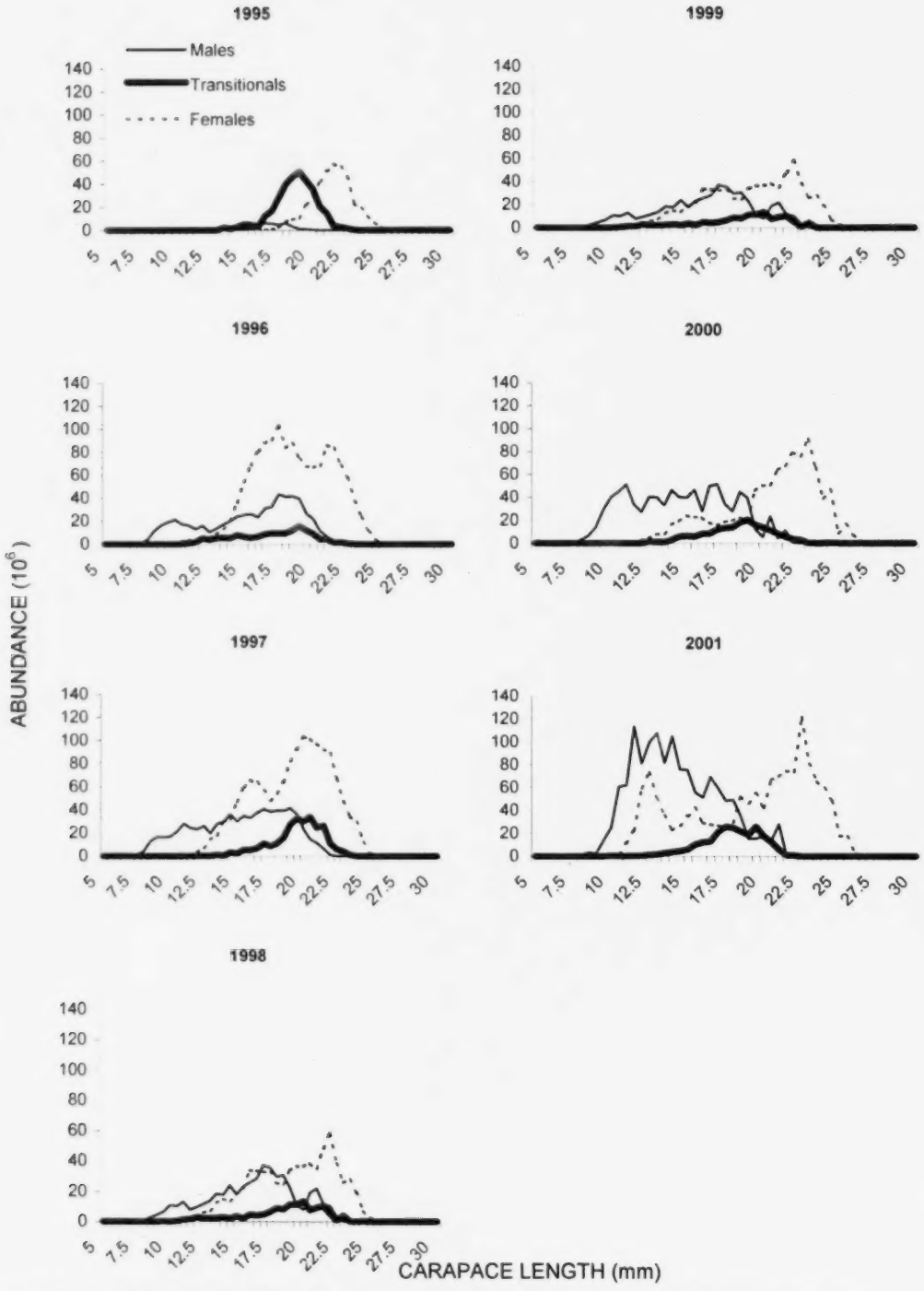


Figure 8. Striped shrimp length frequencies from research samples taken in NAFO divisions 3LNO (SFA 7). Abundances were calculated using OGMAP.

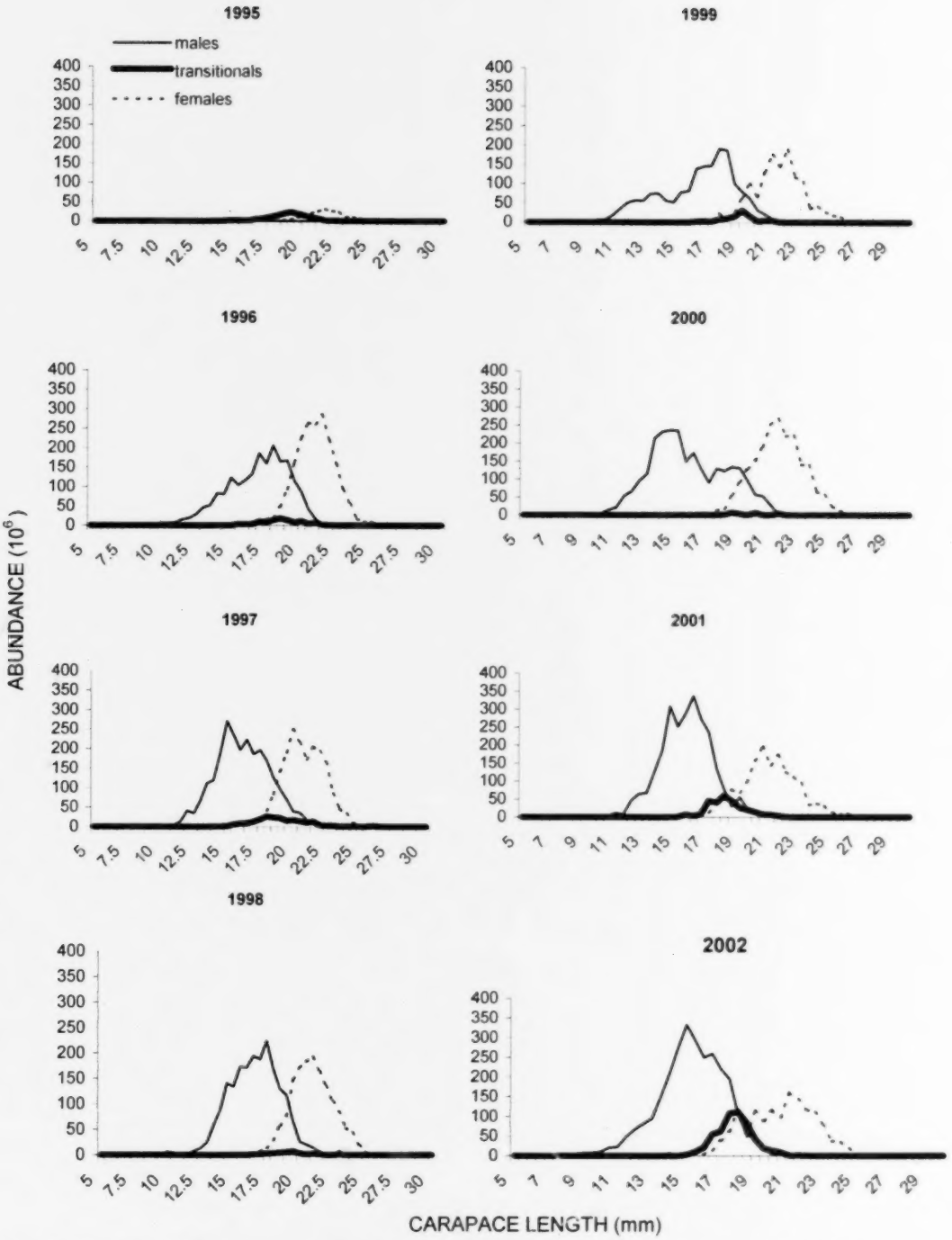


Figure 9. Striped shrimp length frequencies from research samples taken in Hawke Channel + 3K (SFA 6). Abundances were calculated using OGMAP.

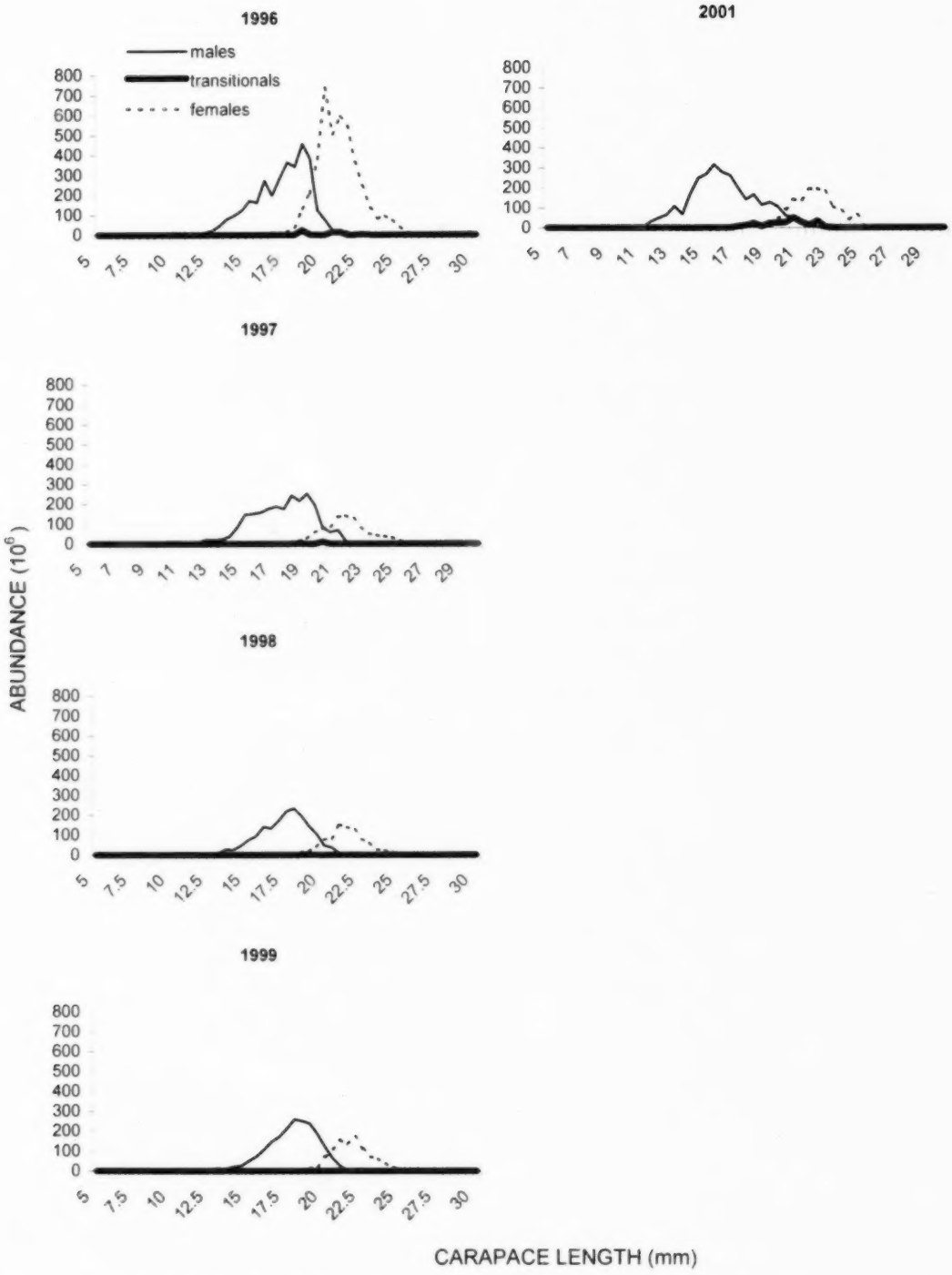


Figure 10. Striped shrimp length frequencies from research samples taken in Hopedale - Cartwright Channels (SFA 5). Abundances were calculated using OGMAP.

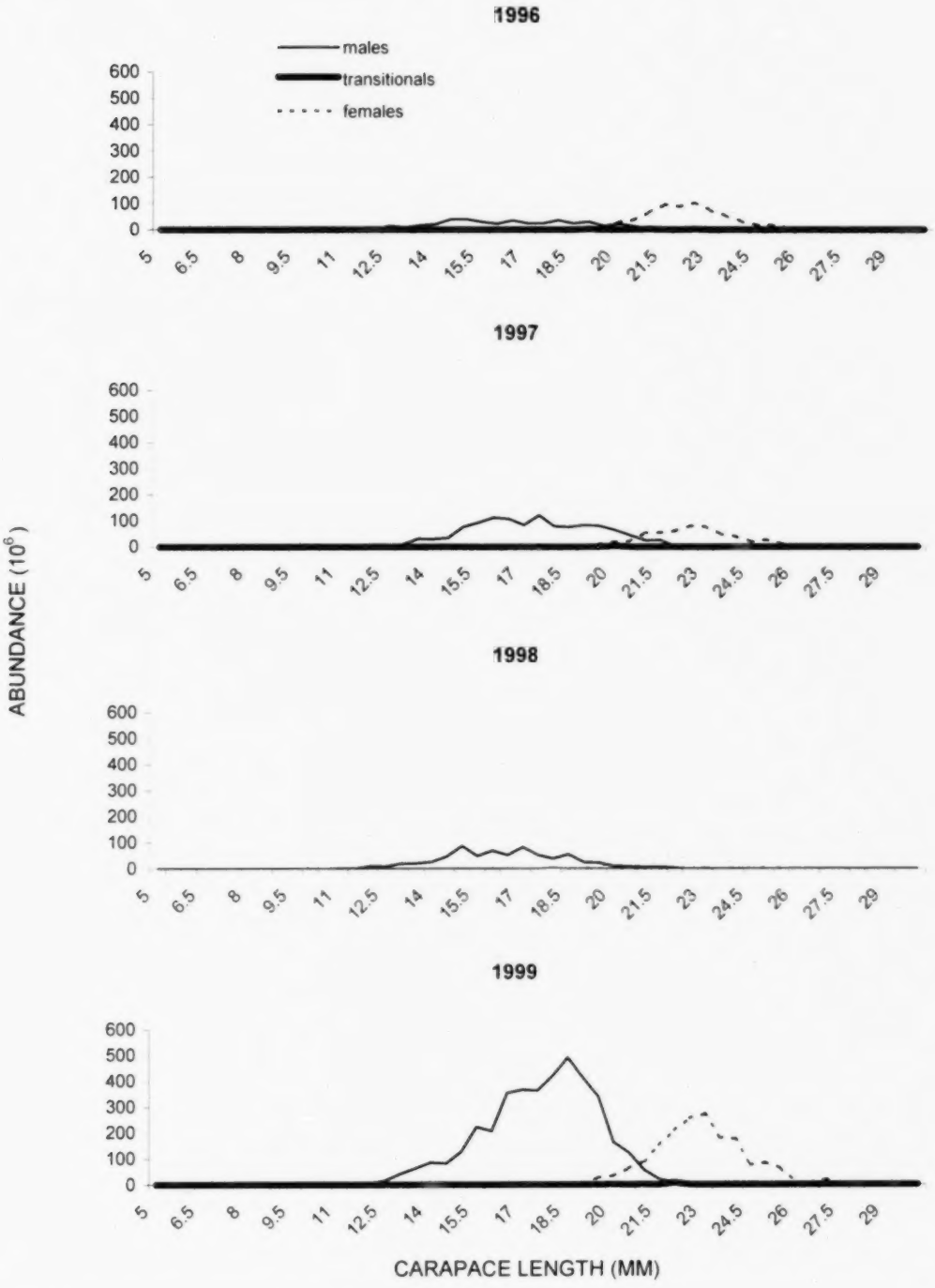


Figure 11. Striped shrimp length frequencies from research samples taken in NAFO division 2G (SFA 4). Abundances were calculated using OGMAP.